Space Weather Technical Forecast

Issued on Saturday, 18 February 2023 at 00:44 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1-G2 Minor/Moderate Storms likely due to CME arrival early Day 1 (18 Feb) and perhaps again Day 3 (20 Feb). M-flares likely, slight chance X-flares throughout (R1-R3 Radio Blackouts).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity is currently High with a long period X2.28 flare, the strongest of the solar cycle so far, peaking at 17/2016 UTC from AR3229 in the northeast. This region is gradually rotating into view, and appears to have some twisting in its magnetic field lines. Further complexity may become apparent as it becomes more clearly visible. There are a total of eight sunspot regions on the visible solar disc. The largest AR3226 has shown a little more magnetic complexity, but remains inactive. The other regions are generally mature and either stable or declining. There are two further regions appearing in the southeast, but it is too early to properly classify these. A very fast CME has emerged in association with the X-flare. Although the majority of this material is directed away from Earth, a halo shock is showing in coronagraph imagery. Assessment of this CME is ongoing.

Solar Wind / Geomagnetic Activity: Solar winds as measured by DSCOVR at L1, continue to be indicative of a High Speed Stream (HSS), likely from the partially obscured coronal hole 76. Wind speeds were slightly elevated to elevated, ranging between 450 and 550 km/s, with density around average. The total IMF strength, Bt, declined from initial Moderate levels at around 15 nT to become weak currently around 4-5 nT. The north-south component, Bz, initially varied moderately between +13/-8nT, before becoming weak and variable. Phi angle was mainly positive (away from the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 0-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES-16 remained at background levels. High energy electron flux (greater than 2MeV) at GOES16 has been at background levels throughout. The associated 24 hour electron fluence has been below the Active (1e8 integrated pfu) threshold, reaching 2.68e6 integrated pfu at 18/0000 UTC on a fairly steady trend.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is likely, with a slight chance of remaining High. The main risk for further significant flaring is AR3229 on the northeast limb.

Solar Wind / Geomagnetic Activity: A CME from the 15th is forecast to arrive at 17/1800 UTC +/- 12 hours. The timing of the arrival is only of moderate confidence. A fast CME from the 16th, has some potential for a glancing impact on the 18th. A recent CME associated with the X2 flare from AR3229 is still being assessed, but there may be some Earth directed component. This could potentially arrive on the 20th. Current slightly elevated to elevated solar winds are due to a coronal hole fast wind and will likely be prolonged through Day 1 (18 Feb) by the CME arrival, before easing during Day 2 (19 Feb). A further coronal hole is likely to enhance solar winds probably during Day 3 (19 Feb), perhaps combined with any CME from the 17th, resulting in

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elevated winds or perhaps even strong wind speeds returning.
Geomagnetic activity is expected to be Quiet to Unsettled, increasing to Active to G1 Minor Storm, with a chance of G2/Moderate Storms with the CME arrival, before gradually easing Day 2. Thereafter becoming somewhat uncertain as the CME from 17th still needs fully assessing, but perhaps increasing again through Day 3 with a risk of G1-G2 Minor to Moderate Storms if this CME does reach Earth.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is most likely to remain at background levels, but with a slight chance of exceeding S1 in response to larger flares. High energy (greater than 2 MeV) electron flux may increase later in the forecast period, but with low confidence due to potential CME arrivals. The associated 24 hour fluence is expected to remain below the Active threshold (1e8 integrated pfu), but perhaps rising later in the period.

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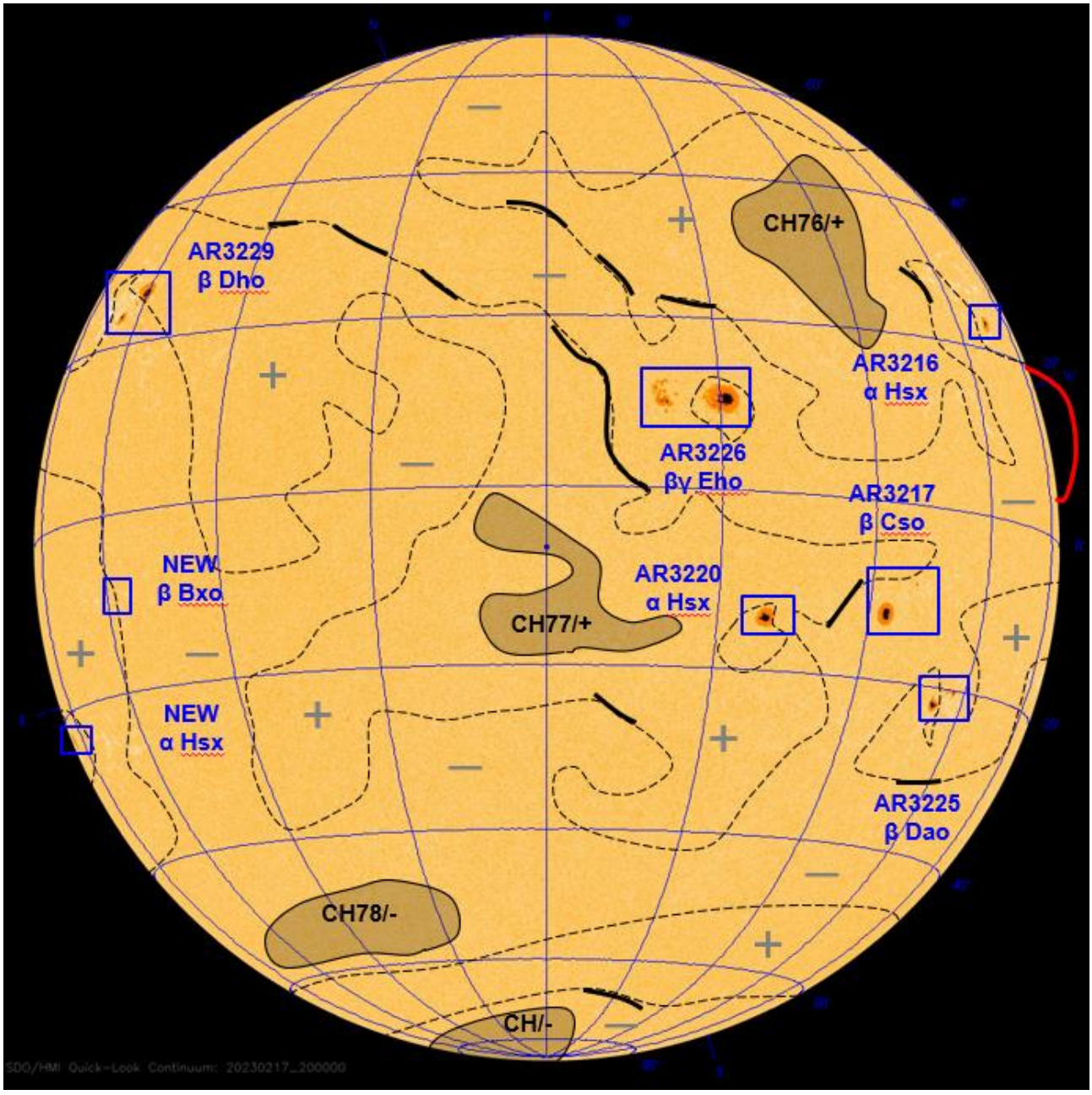
Figure 1. Solar Analysis Valid 17/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME from a filament eruption, just east of the central solar disc is forecast to arrive at 17/1800 UTC +/- 12 hours. This timing of the arrival is only of moderate confidence due to limited available imagery for analysis, resulting in a wide range of potential CME speeds. A fast CME from a filament eruption and associated C9 flare off the northwest disc (near AR3216) on the 16th, has some potential for a glancing impact on the 18th. This could combine with, or be indistinguishable from any previous CME influence, but may increase geomagnetic activity further. A recent CME associated with the X2 flare from AR3229 is still being assessed. The majority of the ejecta is directed away from Earth, however a halo shock is showing in coronagraph imagery which suggests there may be some Earth directed component. This could potentially arrive on the 20th.

Current slightly elevated to elevated solar winds are due to a fast wind originating from a partially obscured coronal hole (CH76) in the northwest disc. The expected CME arrival will likely prolong slightly elevated or perhaps elevated wind speeds through Day 1 (18 Feb), before any CME and CH combined influence starts to ease during Day 2 (19 Feb). However, CH77/+ in the centre disc is then likely to enhance solar winds probably during Day 3 (19 Feb), perhaps combined with any CME from the 17th, resulting in elevated winds or perhaps even strong wind speeds returning.

Geomagnetic activity is expected to be Quiet to Unsettled, increasing to Active to G1 Minor Storm, with a chance of G2/Moderate Storms with the CME arrival, before gradually easing Day 2. Thereafter becoming somewhat uncertain as the CME from 17th still needs fully assessing, but perhaps increasing again through Day 3 with a risk of G1-G2 Minor to Moderate Storms if this CME does reach Earth.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	60	40	60	30
Strong	G3	No	10	5	10	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
15/0815	Partial	Filament	SE	650 km/s	17/1800 +/- 12 hrs	Moderate confidence for timing
16/1250	Partial	Filament	NW	1700 km/s	18/0300+/- 9hrs	Low confidence
18/0239	Full	AR3229	NE	600-1000 km/s	During 20th	Still being assessed

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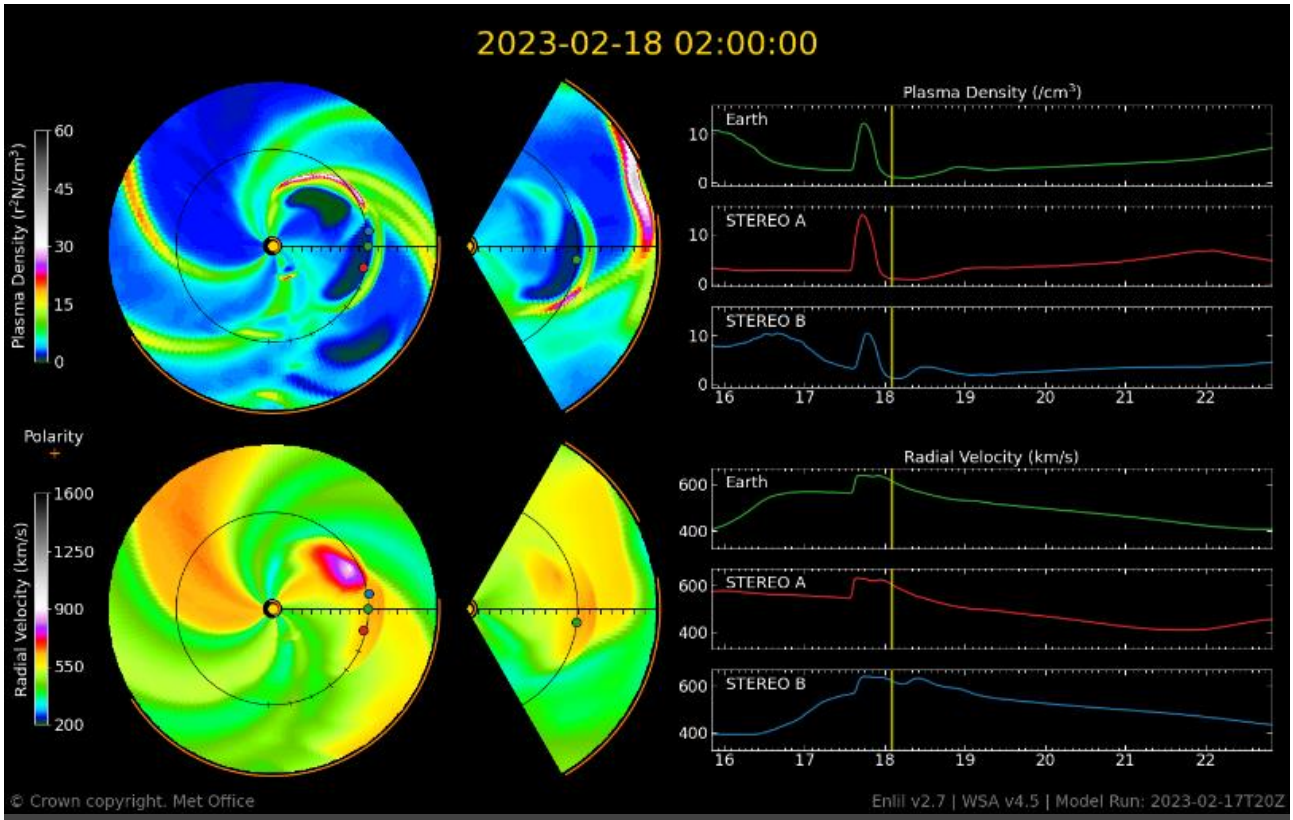
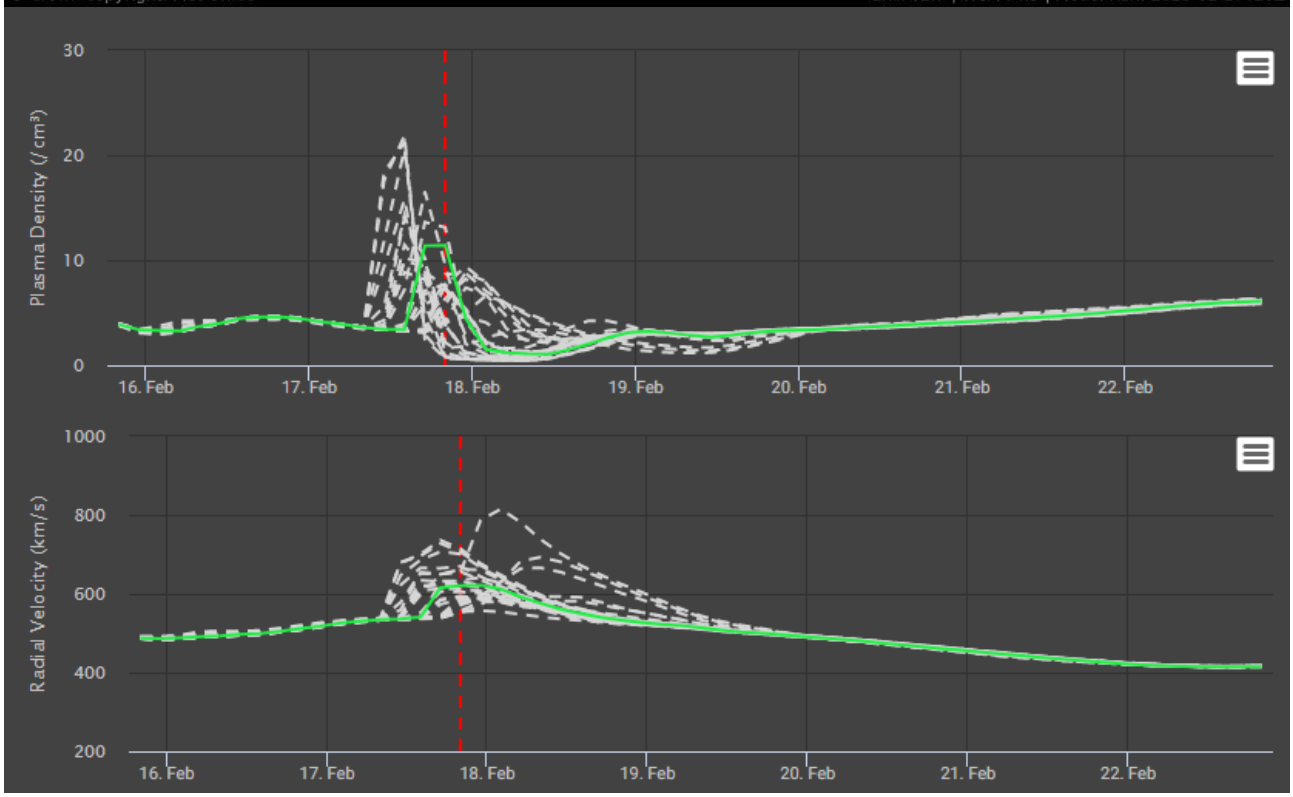
Figure 2: MOSWOC Enlil and ensemble, showing CME from 15th due to arrive any time and CME from 16th likely to miss ahead of Earth. The CME from 17th is not yet modelled in Enlil.





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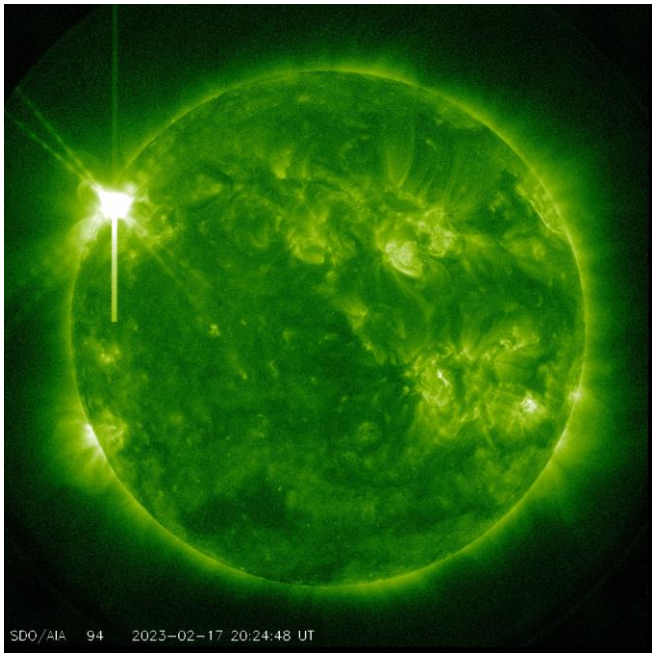
Radio Blackouts - X-Ray Flares:
Solar activity is currently High with an X2.28 flare, the strongest of the solar cycle so far, peaking at 17/2016 UTC from AR3229 in the northeast. Activity is likely to be Moderate, with a slight chance of remaining High.

There are eight sunspot regions on the earth-facing disc. AR3229 is currently classified Dho/Beta, but it is difficult to fully assess due to foreshortening near the limb. Twisting of the magnetic field lines is visible in imagery, and it appears to be aligned more north-south, increasing magnetic shear. This region is likely to be more complex than the current classification. The largest region is AR3226 (Eho/Beta-Gamma) in the northwest. Despite recently developing some minor magnetic complexity it has been stable so far. There is also a new region rotating onto the southeast limb which is not yet fully visible. AR3225 (Dao/Beta) had shown some growth, but appears to have stabilised somewhat in recent hours. Other regions are small and simple or stable.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	60	60	60
Very Active	R3 to R5 X Class	Yes	20	20	20	20

Figure 3: AIA-094 imagery showing the X2.2 flare from AR3229 in the northeast.



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Solar Radiation Storms - (High Energy Protons):
High energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at background levels. The recent X2 flare from AR3229 may increase proton counts, although its location in the eastern hemisphere of the Sun means it is not strongly favoured for connecting to Earth. As such, there is a slight chance of seeing an S1/Minor Storm on Day 1(18 Feb), reducing slightly through Day 2 (19 Feb) unless further large flares occur.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	15	10	10
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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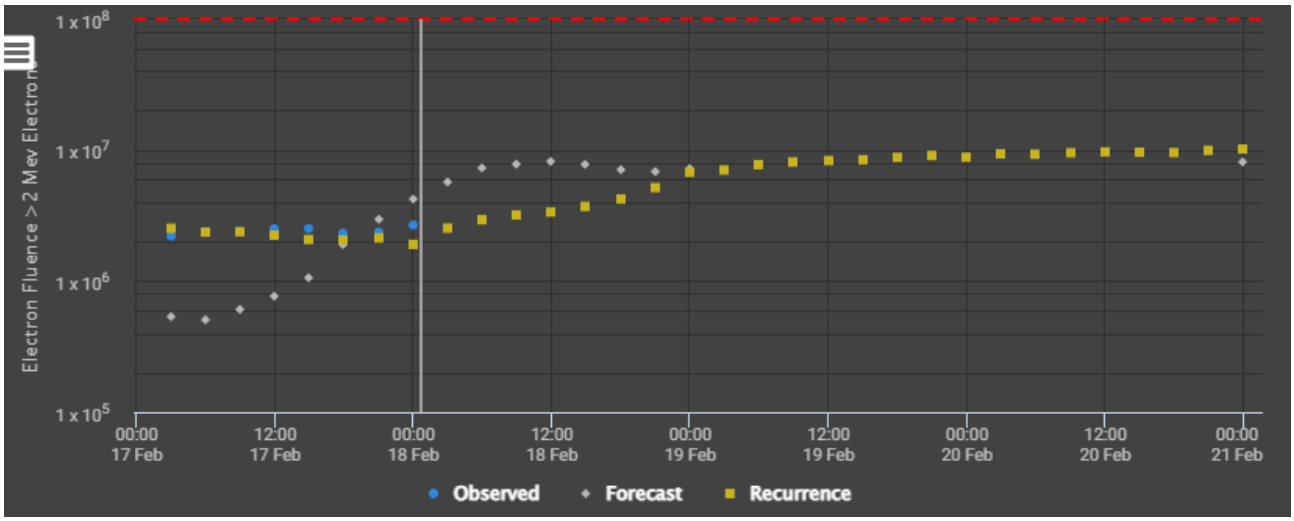
High Energy Electrons Event (≥ 2MeV):
High energy electron flux (greater than 2MeV) observed at GOES-16 is currently at background levels, however the recent fast wind enhancement, along with CME arrivals on previous days, has likely increased count rates at lower orbits. As elevated solar winds decline these increased rates have the potential to expand towards GEO. However, any observed increase in flux is expected to become limited by the forecast CME arrival during Day 1 (18 Feb), with further CME or HSS effects possible through the following days. This could potentially result in a drop out of observed flux with any subsequent recovery difficult to predict at this stage. An increase in flux is possible later in the period, but with very low confidence.

The associated 24 hour fluence is expected to remain below the Active threshold, with only a slight chance of rising above, mainly later in the period. REFM maintains below Active fluence, and this is likely to be a reasonable guide through the period.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	5	10	10
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 4: MOSWOC REFM showing a below Active steady trend through the coming days.



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